

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION WASHINGTON, D.C. 20546

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REPLY TO ATTN OF: GP

TO:

USI/Scient/ific & Technical Information Division

Attention Miss Winnie M. Morgan

FROMS

GP/Office of Assistant General Counsel for

Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No.	8 <u>3</u> 5 3 0, 3 3 6
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Supplementary Corporate Source (if applicable)	
NASA Patent Case No.	8 material substitution and a state of the contract of the con

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes \[\] No \[\]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . with respect to an invention of . . "

Elizabeth A. Carter

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Enclosure

Copy of Patent Gited above

N71-13518

(ACCESSION NUMBER)

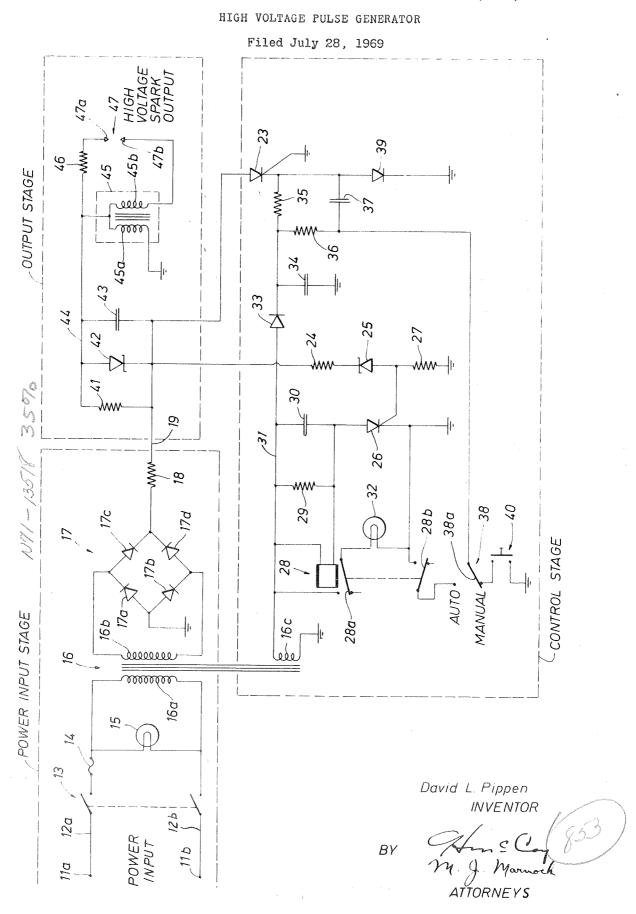
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3,530,336 HIGH VOLTAGÉ PÜLSE GENERATOR David L. Pippen, Las Cruces, N. Mex., assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

Filed July 28, 1969, Ser. No. 845,365 Int. Cl. H05b 41/14

U.S. Cl. 315-

5 Claims

ABSTRACT OF THE DISCLOSURE

A capacitive discharge circuit is employed to produce a controlled, high voltage, fixed energy spark. A fixed voltage for the spark discharge is provided by a storage 15 high voltage spark. Again, however, the emphasis in such capacitor connected in parallel with a Zener diode. Discharge of the capacitor through the primary of an output transformer is controlled by a separately powered control circuit which employs a silicon controlled rectifier (SCR) as a switching device. A Zener diode employed in the control circuit is subject to the storage capacitor voltage and when the desired capacitor voltage is reached, is driven into conduction to fire a second SCR in the control circuit which in turn activates a relay to energize a ready lamp 25 indicating that the circuit is prepared to deliver a fixed energy spark. The charge circuit is manually fired by closing a switch or is automatically fired each time the circuit is prepared to deliver the fixed energy spark by linking the switching mechanism to the relay. After each discharge, the first SCR is automatically commutated by the back EMF of the output transformer and the second SCR is commutated by the AC input to the control circuit.

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates generally to circuitry for 45 producing a high voltage pulse. In particular, the present invention relates to a new and improved circuit for generating a controllable, high voltage spark having a constant known energy output for testing the flash and ignition characteristics of nonmetallic materials in a con- 50 trolled gas environment.

Current space missions under the Apollo program contemplate the use of an artificial oxygen environment in the spacecraft. Because of the danger from combustion in an oxygen environment, great care has been taken to 55 minimize the use of combustible materials and to eliminate sparking and other ignition sources within the confines of the spacecraft. As an incident to such work, tests have been conducted to determine the relative flash and ignition characteristics of various nonmetallic materials contemplated for use within the oxygen environment of

In establishing a standard for relative comparison of the flash and ignition characteristics for different materials, it is necessary to subject the material being tested to a controlled ignition or flash source having a known energy output.

Brief description of the prior art

The majority of prior art systems designed to produce a high voltage spark relate to automotive ignition circuits. 2

Such circuits are designed to produce a timed discharge in a spark plug which in turn ignites a combustible fuel mixture. While a high voltage spark is required in an ignition system, precise control of the spark energy has not been a consideration since fuel ignition may occur over a wide energy range. Moreover, the time of firing of a conventional automotive ignition circuit is governed by engine speed and the capacitive storage means generally employed in such circuits is repeatedly discharged irre-10 spective of the voltage level existing across the system components which further contributes to wide variations in spark energy.

Other discharge or spark producing circuits have been designed for use with flash tubes which are fired by a systems has not been directed toward production of a controlled, fixed energy spark and these circuits consequently include no means which would insure a fixed energy discharge or which would indicate the presence of a predetermined voltage across a dischargeable capacitive circuit.

For testing purposes of the type previously described, it is essential that a spark having a fixed energy be produced. Moreover, since a finite amount of time is required to charge capacitive circuits, some method is required for determining when the spark generator is properly charged and prepared to deliver a fixed energy spark. A further requirement is that the system be capable of delivering the required spark at the desired time and that such time be either manually or automatically controlled.

SUMMARY OF THE INVENTION

A power transformer having a single primary and two secondary windings is employed in a power input stage to step-down a conventional power supply to provide two lower voltage AC outputs. The output of one secondary is full wave rectified by a diode bridge to power the components in the output stage of the circuit where a high voltage spark is to be produced and the output of the other secondary powers the components of a control circuit which regulates the firing of the spark. A storage capacitor in the output stage charges causing a Zener diode in the control stage to break down and conduct which permits a voltage to be developed between the gatecathode junction of a silicon controlled rectifier (SCR). The voltage across the storage capacitor continues to increase until a Zener diode in parallel therewith breaks down a clamp a fixed voltage across the capacitor. At this point, the gate-cathode voltage across the control stage SCR increases sufficiently to fire the SCR allowing it to conduct current during the subsequent half cycle of positive voltage supplied by the control stage secondary. Current flow through the SCR energizes a relay which closes a circuit to light a lamp indicating that the circuit is prepared to produce the desired spark. An RC circuit connected in parallel with the relay prevents the relay from dropping out during the negative half cycle output of the control stage secondary and ensures sufficient current flow through the SCR to maintain it in a conductive

A second SCR is included in the control stage and is employed as a switching means for discharging the output stage storage capacitor. The second SCR is connected through a capacitive circuit to a rectifier with the capacitive circuit being charged from the output of the control stage secondary through a half wave rectifier and capacitive filter circuit. By means of a suitable switch, the capacitive circuit is discharged causing the second SCR to be fired into conduction which in turn discharges the output stage storage capacitor through the primary winding of an output stage transformer. A high voltage pulse

is thereby induced in the secondary of the output stage transformer to create the desired spark across a pair of spaced electrodes with spark energy being preset by means of a resistor connected in series with the spark gap.

After the discharge, the back EMF of the transformer primary commutates the second SCR and the Zener diode in the control stage stops conducting causing the first SCR to be reset by the subsequent negative going output from the control stage secondary. When this SCR stops conducting, the relay drops out causing the indicator lamp 10 to extinguish and the circuit components begin to recharge for the subsequent cycle.

The switch employed to discharge the capacitive system and thus to produce the desired spark in the output stage may be manually or automatically operated. When 15 automatic switching is to be employed, the capacitive system is automatically discharged by the switching action of the control stage relay which occurs automatically each time the circuit components have been charged to the desired values.

By means of the high voltage pulse generator of the present invention, a controlled energy spark may be produced either manually or automatically at a desired point in time. The indicator lamp provides a readily discernible signal that the circuit components have been charged to 25 the desired values. Moreover, the critical charge across the output stage capacitor is clamped at a fixed value which produces a constant energy spark, and when automatic firing is employed, the capacitor is discharged only after this fixed voltage level has been reached to ensure 30 a constant energy output.

The elements employed and their manner of interconnection ensure positive resetting of the silicon controlled rectifiers after each cycle in a simple and direct manner and without exceeding design ratings. The individual com- 35 ponents employed in the circuit are conventional and may be economically assembled to produce a simple and efficient spark generator having the desired ability to produce a controlled, fixed energy spark.

Other advantages and features of the invention will be- 40 come apparent from the following description and related schematic drawing of the circuit.

BRIEF DESCRIPTION OF THE DRAWING

The figure is a schematic circuit diagram of a high $_{45}$ voltage pulse generator constructed in accordance with the teachings of the present invention.

DESCRIPTION OF THE PREFERRED **EMBODIMENT**

With reference to the figure, the high voltage pulse generator 10 of the present invention is illustrated as generally including a power input stage, a control stage and an output stage. The power input stage functions generally to transform and rectify an alternating current input from 55 a conventional AC power source (not illustrated) to provide the power requirements of the control and output stages while the control stage regulates the firing of a high voltage spark which is produced in the output stage.

The input stage includes two input terminals 11a and 60 11b which are adapted to be connected to a suitable source of alternating current power such as a conventional 117 v. AC power supply. Conductors 12a and 12b are connected to the input terminals 11a and 11b respectively for conducting the input power to the circuit 10 and a 65 manually operated switch 13 is employed in series in the conductor 12a to electrically connect and disconnect the circuit 10 and the power supply. A fuse 14 is connected into the line 12a in series to protect the circuit 10 from a current overload in the power stage. The presence of 70 power input to the power stage of the circuit 10 is signalled by means of an indicator lamp 15 connected between the lines 12a and 12b. It will be evident that the lamp 15 will be energized only when an adequate power

switch 13 is closed and the fuse 14 is intact and conducting current.

A magnetic core, step-down power transformer 16 having a single primary winding 16a and two secondary windings 16b and 16c is employed to convert the input power appearing at the primary winding 16a to lower voltage outputs at secondary windings 16b and 16c. The output of secondary winding 16b is conveyed to a diode bridge 17 which provides full wave rectification of the alternating current appearing across the winding 16b. The bridge 17 is conventional and includes four semi-conductor diodes 17a, 17b, 17c and 17d interconnected as illustrated with the anodes of diodes 17a and 17b connected to ground. The rectified output from the bridge 17 is conveyed through a series resistor 18 to a conductor 19 which forms the output of the power stage.

The direct current voltage appearing on conductor 19 is supplied to the control stage of circuit 10 through the anode of a grounded gate, silicon controlled rectifier (SCR) 23 and a resistor 24. The cathode of a Zener diode 25 is connected to the second end of the resistor 24 and its anode is connected to the gate of a second SCR 26. A grounded resistor 27 is connected to the gate of SCR 26 to provide gate voltage and the anode of the SCR is connected to a double pole, single throw relay 28 having dual switching elements 28a and 28b. The anode of SCR 26 is also connected to a resistor 29 and capacitor 30 which are connected in parallel with relay 28 by a conductor 31. The latter conductor carries the alternating current output of the secondary winding 16c of power transformer 16.

When relay 28 is energized, relay switch element 28a applies the alternating current output appearing on line 31 to a ready lamp 32. The second relay switch element 28b is ganged with the element 28a and is drawn to ground when the relay 28 is energized for a purpose to be hereinafter explained. The anode of a semi-conductor diode 33 is connected to the line 31 and its cathode is connected to a grounded capacitor 34 and to resistors 35 and 36. Resistor 36 is connected to a capacitor 37 and to the switch element 38a of a manually operated mode control switch 38 while resistor 35 and capacitor 37 are connected to the anode of a semi-conductor diode 39 having its cathode connected to ground.

The mode control switch element 38a is illustrated in the position employed for manual firing of the circuit. In the latter mode, a high voltage spark in the output stage is manually triggered by depressing a quick return, normally open pushbutton switch 40 which completes a conducting path to ground. When switch element 38a is moved to the AUTO position, the high voltage spark is automatically triggered in the control circuit by the action of relay 28 which when energized, draws relay switch elements 28a and 28b into electrical contact with line 31 and ground respectively as will hereinafter be more fully described.

The output stage of the circuit of the present invention includes a resistor 41, Zener diode 42 and capacitor 43 connected in parallel between the conductor 19 and a conductor 44. The output stage also includes a two-winding, magnetic core transformer 45 having a primary winding 45a connected between conductor 44 and ground, and a secondary winding 45b connected to conductor 44 and across a series circuit formed by a resistor 46 and two spark gap terminals 47a and 47b of a spark gap 47.

The operation of the high voltage pulse generator 10 of the present invention will first be described with the mode control switch element 38a in the manual mode as illustrated in the figure. With power switch 13 closed and a suitable source of alternating current connected to the input terminals 11a and 11b, capacitor 43 in the output stage begins to charge through resistor 18 and the primary winding 45a of transformer 45 to the peak DC voltage supplied by the bridge 17. In the control stage, the AC source is connected to the terminals 11a and 11b, the 75 voltage appearing across the secondary winding 16c is half

wave rectified and filtered by diode 33 and capacitor 34 respectively. As output stage capacitor 43 charges, capacitor 37 in the control stage charges through diode 39 and resistor 36 toward the DC voltage supplied by diode 33 and filter capacitor 34.

While capacitor 43 is charging, the reverse voltage across Zener diode 25 increases until its breakdown voltage is reached. The resultant cathode to anode current through Zener diode 25 and resistor 27 produces a cathode to gate voltage in SCR 26. As the voltage developed 10 across output stage capacitor 43 continues to increase, the breakdown voltage of Zener diode 42 is exceeded and the diode is biased into conduction to clamp the voltage across capacitor 43. With capacitor 43 clamped to the breakdown voltage of diode 42, the voltage developed 15 across resistor 27 in the control circuit becomes sufficient to trigger SCR 26 into its conductive state. With SCR 26 in a conductive state, anode to cathode current flow occurs during the first positive half cycle output from secondary winding 16c which energizes relay 28. Capacitor 20 30 prevents relay 28 from dropping out or de-energizing during the neagtive half cycle output of secondary winding 16c and resistor 29 assures sufficient latch in current for SCR 26. Energizing the relay 28 draws switch element 28a into contact with the AC output of secondary 25 winding 16c which lights ready lamp 32 indicating that the circuit 10 is prepared to be fired.

The circuit 10 is manually fired by momentarily depressing switch 40 which applies the positive side of the voltage across capacitor 37 to ground. This places a reverse bias on diode 39 and applies a voltage pulse to the cathode of SCR 23. The pulse, which is negative with respect to the gate of SCR 23, triggers the SCR into conduction which in turn discharges output stage capacitor 43 through diode 39 and the primary winding 45a of transformer 45. Current flow through winding 45 induces a voltage across secondary winding 46b which in turn generates the desired high voltage spark between spark gap terminals 47a and 47b. Resistor 46 limits the output energy of the resulting spark to the desired level.

Immediately after discharge of capacitor 37, a positive voltage is developed across resistor 35 and is applied to the cathode of SCR 23 to provide reverse bias for the gate-cathode junction. At this point, resistor 18 provides sufficient power supply impedance so that the back EMF developed in the primary winding 45a of transformer 45 commutates SCR 23. Discharge of the voltage across output stage capacitor 43 cuts off current flow through Zener diode 25 and resistor 27 in the control stage to remove the gate voltage from SCR 26. The subsequent neagtive half cycle output from secondary winding 16c then commutates SCR 26 and relay 28 drops out to extinguish the ready lamp 32. The circuit 10 then begins to recharge in the previously described manner.

The circuit 10 may be made to fire automatically by moving mode switch element 38a to the AUTO position. In the latter position, energizing of relay 28 automatically draws relay switching element 28b into momentary engagement with ground to fire the circuit 10. It will be understood that relay switching element 28b is automatically released after making momentary connection with ground and thereafter is returned to the position illustrated in the figure for a subsequent sparking cycle.

In one form of the circuit 10 of the present invention, designed for use with a conventional 117 v. AC power 65 supply, a one amp fuse and a 117 v. AC lamp may be employed for the fuse 14 and lamp 15 respectively. A Thordardson GGU power transformer or equivalent having a 117 v. AC primary, and 30–0–30 and 6.3–6.3 v. AC secondaries may be employed for the power transformer 16 with the series connected output of the two 30 v. AC windings forming a 60 v. AC input to the bridge 17 and the series connected output of the two 6.3 v. AC windings supplying 12.6 v. AC to conductor 31. Motorola MDA 942–2 semi-conductor diodes or equivalents hav-

ing 1.5 amp and 100 peak inverse voltage ratings may be employed for the diodes 17a-17d of bridge 17 to provide a full wave rectified output of approximately 84 volts to resistor 18.

The resistors employed in circuit 10 have the following values:

Resistor	Rating in ohms	Power rating, watts
18	 2k	5
24	 60k	1/2
27	 30k	$\frac{1}{2}$
29	 1k	$\frac{1}{2}$
35	 300	1/2
36	 120	2
41	 1M	$\frac{1}{2}$
46	 68k	1/2

Zener diode 25 is a 50-watt Zener diode having a breakdown voltage of 33 volts while Zener diode 42 is a 50watt Zener diode having a breakdown voltage of 36 volts. The breakdown voltage of Zener diode 25 is lower than that of Zener diode 42 since Zener 25 must begin conducting before the voltage of capacitor 42 is clamped by conduction of Zener 42.

The capacitors employed in the cricuit 10 have the following values:

	Capacitor	Capacitance rating in microfarads	Power rating, wv.
	30	100	25
	34	250	25
`	37	1	25
,	43	5, 300	50

General Electric silicon controlled rectifiers C-30B and C106-B or equivalents may be employed for SCR's 23 and 26 respectively and G.E. semi-conductor diodes 1N91 and 1N1613 or equivalents may be employed for diodes 33 and 39 respectively. Relay 28 may be any conventional double pole, single throw, relay having a 12-volt D.C. rating and output stage transformer 45 may be a Mallory F-12T transformer or equivalent having a 250:1 turns ratio.

With the components having the previously described ratings, a spark is produced across gap 47 having an approximate output energy of 65 millijoules. The energy of the spark may be increased by reducing the value of resistor 46 with an approximate maximum output energy of 350 millijoules being produced when the resistance of resistor 46 is decreased to zero ohms. The output energy of the spark may also be varied by changing the value of capacitor 43 with a decrease in capacitance causing a decrease in the spark energy and spark duration.

When the circuit 10 is in the automatic mode, the repetition rate is approximately seven seconds with the previously described component rating. The repetition rate may be altered by changing the value of resistor 18 provided that the resulting resistance value is not reduced below that required to commutate SCR 23 with the back EMF of transformer winding 45a.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim

1. A high voltage pulse generator comprising:

capacitive means for storing an electrical charge to produce a voltage across said capacitive means, said capacitive means including a storage capacitor; first regulating means included with said capacitive means for fixing a predetermined voltage across said capacitive means while electrical power is continuously supplied to said capacitive means, said first regulating means including an electrical voltage limiting means connected in parallel with said storage capacitor;

10

control circuit means connected with said capacitive means for controllably discharging said capacitive means:

second regulating circuit means included in said control circuit means and connected with said capacitive means for activating an electrical control circuit while a predetermined voltage exists across said capacitive means, said second regulating circuit means including a voltage sensitive electrical circuit connected to said storage capacitor for conducting current only when the voltage across said voltage capacitor exceeds a predetermined voltage, and a signalling circuit means connected with said voltage sensitive electrical circuit for automatically indicating the presence of a predetermined voltage across said stor- 15 age capacitor when said voltage sensitive electrical circuit conducts current;

switching circuit means included in said control circuit means and connected with said capacitive means for controllably discharging said capacitive means, 20 said switching circuit means including an electrical switching means which is fired into a conductive state by an electrical trigger signal, trigger signal circuit means connected with said electrical switching means for providing an electrical trigger pulse to fire said electrical switching means into conduction, and control switch means for activating said trigger circuit means to produce said electrical trigger signal, said control switch means including an automatically operable discharge switch connected with said second 30 regulating circuit means for automatically controlling the discharge of said storage capacitor each time a predetermined voltage exists across said storage capacitor.

2. The high voltage pulse generator as defined in claim 35 1 wherein:

(a) said control switch means further includes a manually operable discharge switch for manually controlling the discharge of said storage capacitor; and

(b) said control switch means further includes a mode 40 switch for switching discharge control to said manually operable discharge switch or to said automatically operable discharge switch.

3. The high voltage pulse generator as defined in claim 2 wherein:

(a) said electrical voltage limiting means includes a first Zener diode connected in parallel with said storage capacitor;

(b) said voltage sensitive electrical circuit includes a second Zener diode connected with said storage ca- 50 pacitor:

(c) said signalling circuit means includes a first silicon controlled rectifier connected with said second Zener diode and having its gate voltage determined by current flow through said second Zener diode;

(d) said signalling circuit means further includes relay switching means activated by current flow

through said first silicon controlled rectifier for energizing a ready lamp and for operating said automatically operable discharge switch; and

(e) said electrical switching means in said switching circuit means includes a second silicon controlled rectifier which is fired into electrical conduction by said trigger signal circuit means.

4. The high voltage pulse generator as defined in claim

3 further including:

(a) a source of direct current power connected with said capacitive means for charging said storage capacitor:

(b) a pulse transformer connected with said capacitive means for generating a high voltage output when said storage capacitor is discharged; and

(c) a source of alternating power for powering said control circuit means.

5. The high voltage pulse generator as defined in claim 4 wherein:

(a) said sources of direct and alternating current power include a power transformer having at least one primary and at least a first and a second secondary winding;

(b) said first secondary winding is connected across a semiconductor diode bridge for converting the alternating current output of said first secondary winding to full wave rectified direct current power at the

output of said bridge;

(c) the output of said bridge is connected through a first series resistor to one end of a parallel output circuit which includes said first Zener diode, said storage capacitor and a second resistor with the other end of said parallel output circuit being connected to said pulse transformer;

(d) said pulse transformer includes primary and secondary windings with its primary winding connected in series with a third resistor and its secondary winding connected in parallel with a spark gap;

(e) said second secondary winding of said power transformer is connected to said control circuit means to provide alternating current power to said control circuit means; and

(f) said second secondary is connected to a half wave rectifier for providing direct current power to said

trigger signal circuit means.

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JERRY D. CRAIG, Primary Examiner

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307-252; 328-67